SCIENCE EDUCATION AT SECONDARY LEVEL IN INDIA, CHINA AND JAPAN: A COMPARATIVE STUDY

SYNOPSIS OF THE THESIS SUBMITTED FOR

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Synopsis

Introduction

The importance of comparative studies have been recognized worldwide and increasingly paying more attention. As science and technological education helps in economic productivity and progress of a nation, each country tends to compare their science education system with the high performing nation in science. This type of comparison identifies the systems in common and contrast as well as finds the gaps. The outcome of such studies are helpful for stakeholders and government authorities for planning and educational policymaking. The researcher has followed qualitative research methodology and comparative strategy for analysing qualitative data used in the research study. The study is delimited for Science education at secondary level in India, China, and Japan.

Summing up

At the present scenario, both China and Japan are the forerunner of science education being more aligned with the international trend of 21st century appropriate competency-based science standards focusing on Sustainable Development Goals. Whereas, India is lagging in this aspect although the latest NEP-2020 advocated for huge changes in the Indian school education system including science education and its effects will be evident in near future.

The study discusses the historical curriculum development of the selected three countries.

The study discusses the system and features of PD of secondary science teachers of the selected three countries and makes a comparative evaluation.

This study presents the performances in IJSO, IPhO and IChO of the three selected countries and makes a comparative analysis to determine whose performance is better. Among the three countries, overall performance of China is outstanding in IPhO and IChO whereas performances of Indian students are excellent in IJSO. Both India and Japan are far behind of China in the medal tally in IPhO and IChO. Furthermore, Chinese and Japanese students are the high achievers in International science assessment tests like PISA, TIMSS.

The extract of findings based on research objectives are summarized below-

Objective 1: To study the contemporary secondary science curriculum of India, China and Japan with a comparative approach.

The study firstly describes the school education structure prevalent in India (5+3+2+2 system operated till date as NEP 2020 was not implemented throughout all the schools in India), whereas both China and Japan both following 6+3+3 school education structure.

From the curricular objectives, it is clear that Indian science curriculum emphasized more on exam-centric rote learning over creative science learning and this fact is supported by the fact that laboratory class for science subjects is not mandatory up to class 10, rather it starts from senior secondary level. Whereas although China emphasized on rote learning but their science teaching learning environment is more creative and interesting as students learn through hands-on experiments starting from lower secondary level and onwards. In Japan, creative and aesthetic values gets more priority over rote learning. Japanese students learn science concepts through experimentation starting from lower secondary level onwards and can interlink between science, technology, and society.

Both Chinese and Japanese science curriculum competences are more aligned with the OECD's CCM framework 2030. Both Chinese and Japanese school science curriculum structured with STEM enabled education whereas in India, there is no provision or recommendations through NEP for STEM enabled school science curriculum.

Objective 2: To study the system and features of professional development of science teachers at secondary level in India, China and Japan.

The study analyzes several important features of PD of secondary science teachers existed in India, China and Japan. In India, PD of science teachers are mainly theoretical trainings and these were also not compulsory and hence there was less chances of developing science teaching efficiency through PD programs.

There are several PD acts or laws exist in both China and Japan and their PD systems are more systematic and organized. Some unique features like one to one mentoring system for novice teachers, ranking or promotion system for in-service teachers, teaching research system, collaborative activities etc. existed in China and Japan.

Japan originated lesson study concept and according to this concept, science teachers improve their teaching learning fruitfully by researching their daily lessons, China followed Japan and they implemented lesson study in their own cultural setting and became very much successful. In India, NEP 2020 recommends for 50 hours of PD programs in a year for teachers including secondary science teachers and are several changes aligned with the 21st century enabled teaching skills as prevalent in developed country like Japan and most competitive country like China.

Objective 3: To investigate the level of performances in international science Olympiads [IJSO (International Junior Science Olympiad), IPhO (International Physics Olympiad), and IChO (International Chemistry Olympiad)] between India, China and Japan.

The study analyzes the past performances of India, China and Japan in the international science Olympiad competitions. Here the study considered in IJSO, IPhO, and IChO competitions for a comprehensive comparison.

In IJSO competitions performances of India was far better than China. India's consistent splendid performances in IJSO are mainly due to several factors like organizing national level standard NSEJS examination for selecting meritorious students and to prepare them through orientation camps and practical trainings according to IJSO standards. Whereas, such extensive preparation of talented students is not evident in China. Japan never took part in IJSO until the last IJSO competition 2024 held in Romania.

In IPhO competitions, Chinese student's performances placed their country in top three positions most of the times. Medal tally and country's position showed that China has bagged 151 gold medals from 37 participations whereas India bagged 51 gold medals from their 25 participations and Japan bagged 17 gold medals from their 21 participations. China most frequently achieved 1st ranking in IPhO competition years since their first participation. India never achieved country wise 1st ranking in IPhO competitions and their highest ranking was 2nd and it was three times in 2001, 2009 and 2018. Japan also never achieved 1st position and their highest rank was 5th in the IPhO competition year 2007. India performed little bit better than Japan in IPhO competition but both India and Japan both remained far behind when compared to China in the aspects of medal tally, position of country and number of absolute winners in those prestigious competitions.

In IChO competitions, china showed very impressive resilience performances by bagging 115 gold medals from their 37 participations, India bagged 29 gold medals from their 25 participations and Japan bagged 25 gold medals from their 22 participations. India never achieved country wise 1st ranking as well as never produced absolute winners. Japan achieved 1st ranking once in 2022. Whereas, China's splendid performances were reflected by achieving 1st ranking in most of their participating years. Although Japan joined late in IChO competition but their achievement and improvement is little bit better than India.

Concluding remarks and recommendations:

China being the second highest populated country after India in the world (Worlometer, 2024) have most number of high school students and they have achieved magnificent performances in international science Olympiad competitions like IPhO and IChO competitions. But China's performances in IJSO is not satisfactory and this may be due to their systematic student preparation for IJSO is not evident like IPhO and IChO. China has advanced globally rich science syllabus, competitive mindset, their hard work, and most importantly opportunities of science teaching learning through hands-on experiments from lower levels. India's performances with respect to China is not satisfactory in IPhO and IChO competitions, although Indian students always do excellent performances in IJSO than China. Some of the fruitful actions may be helpful for better performances of India in IPhO and IChO competitions-

- To reach the global standard of school science education, Indian students should take part in international science assessment tests like PISA, TIMSS regularly and hence the effectiveness of science curriculum may be judged compared to high performing countries (like China and Japan) and the weaknesses should be rectified.
- Science curriculum should be more flexible as India is a diversified country and priority should be given to the local level teachers while selecting curriculum and implementing in a social context as prevalent in Japan.
- In India, the knowledge gap between secondary and senior secondary science should be reduced and as a result, students can easily cope up with vast syllabus at the senior secondary level.
- The science teacher's teaching mostly followed the teacher-centric pedagogical approach instead of student-centric approach and hence cannot attain the social, cultural and contextual goal and perspective of our society. Diversified needs of the students should get priority while teaching science topics.
- In-service teachers should be encouraged for their higher studies and ranking or promotion system should be implemented and more benefits should be given to them accordingly as the system existed in China. Hence, teachers may be more motivated to enrich their teaching through various CPD programs.
- To improve science-teaching quality, science teachers should be observed and evaluated frequently by their superiors as the system existed in China and Japan.

- In Indian schools, practical examination for science subjects starts from class 11, if science teaching carried out with hands-on practical experiments from class 9 or even from the lower classes, meritorious students will become more interested and learn physics and chemistry joyfully then this will help them for experiment test in international competitions.
- At senior secondary level (classes 11 & 12), students have to complete huge theoretical syllabus (more weightage) and as a result experimental part (less weightage) may be neglected. Therefore, there must be a balance between theory and experiment part and hence it will be beneficial for competing in international science Olympiad exams.
- There is very rare possibilities of practicing difficult problems of science at the secondary level (class 9 & 10), so there should be All India Junior Science and Mathematics Olympiad exam this may help students to be acquainted with the international science Olympiads and may improve the competitive Olympiad culture throughout the country.
- Due to language problem, meritorious students from different state boards are lagging in taking part in national science Olympiad exams and hence these exams confined to limited gifted students. Any steps should be taken to extend the opportunity to take part for most of the Indian youth talents.
- Duration should be longer for practical training camps of different stages of science Olympiad preparation.
- Training centers with modern instruments for experimentation should be increased.
- National Olympiad winners should get more reward like advantage for taking direct admission in higher education institutions of their concerned subjects (like China and Japan). Very recently, IITM has launched a program namely, 'Science Olympiad Excellence' (ScOpE), in which the students with excellent performances in national and international Olympiad examinations will get the golden opportunity to take direct admissions into IITM without JEE (Advanced) rank starting from 2025-2026 session. Olympiad achievers will get the chance to take admission in various academic and skill based disciplines (IITM, 2025, March 10). Such type of more initiatives should have taken by the prestigious higher education institutions offering higher degrees in Science and Technology.

Conclusion

The study presents its new findings in varied categories like historical development of science education, curricula, professional development of secondary science teacher and performances of international science Olympiads (like IJSO, IPhO, and IChO) of the selected countries, namely, India, China, and Japan.

Last 10 years (2014-2024) performance comparison of three countries showed that both India and Japan are improving in IPhO and IChO competitions but until now remain far behind of China.

India, China, and Japan being the three Asian countries started their science education reforms almost in the contemporary period back. But China with their attitude of hard labour and rich competitiveness they reshaped their science curriculum, professional development system of science teachers and pedagogy in a fruitful way and as a consequences their students performs splendidly in the international science Olympiads for the last few decades. Japan also made a significant development of science and technology education with their advanced science curriculum pedagogy and lesson study approach in PD system. On the other hand, in India theoretical part of science curriculum get priority than the experimental part, so India should follow China and Japan for science teaching learning through creativity and experimentation stating as early as from the lower secondary (class 9-10). NEP 2020 recommended for reform of PD system of teachers through mandatory PD activities and the effect of this recommendation should be observed very near future after implementation throughout Indian schools. The Japanese education system is continuously evolving, reflecting societal changes, scientific innovations and technological advancements.

China's "Gaokao" entrance examination is one of the toughest examination in the world and preparing for this exam becomes helpful for the students for in-depth learning in science and mathematics. India also have one of the toughest entrance examination viz. "IIT-JEE" to qualify this exam competency-based application oriented science topics should be introduced starting from the lower classes science curriculum in India. Therefore, by enriching the science curriculum and teaching-learning standards at the secondary level, the young minds will be more interested and motivated to pursue higher studies in science and technology and consequently, it will be the great profit for a society through advancements of scientific and technological innovations.

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